CLAIMS

What is claimed is:

1. An apparatus comprising:
   a) a bulk element having a device surface and a bottom surface, disposed below said device surface;
   b) a support; and
   c) at least one hinge, which is disposed below said bottom surface, and which is coupled to said bulk element and to said support, thereby suspending said bulk element from said support.

2. The apparatus of claim 1 wherein said bulk element comprises single-crystal silicon.

3. The apparatus of claim 1 wherein said device surface is reflective.

4. The apparatus of claim 3 wherein said device surface comprises a reflective layer.

5. The apparatus of claim 4 wherein said reflective layer comprises a material selected from the group consisting of gold, aluminum, silver, and copper.

6. The apparatus of claim 1 wherein said at least one hinge is formed from a material selected from the group consisting of polysilicon, polyoxide, nitride, silicon nitride, silicon dioxide, silicon oxynitride, single-crystal silicon, and metals.

7. The apparatus of claim 1 wherein said support is made of silicon.

8. The apparatus of claim 1 wherein said support includes a cavity, and wherein said at least one hinge is disposed within said cavity.

9. The apparatus of claim 8 wherein said support further comprises at least one electrode disposed in said cavity, for causing said bulk element to be actuated.

10. The apparatus of claim 8 wherein said cavity is formed by a plurality of sidewalls.

11. The apparatus of claim 10 wherein said at least one hinge comprises first and second hinge elements, and wherein each of said hinge elements is coupled to a unique one of said plurality of sidewalls.

12. The apparatus of claim 11 wherein each of said sidewalls includes a ridge portion that is inwardly projecting, and wherein each of said hinge elements is coupled to a unique one of said ridge portions.

13. The apparatus of claim 12 wherein each of said hinge elements is further coupled to said bottom surface.

14. The apparatus of claim 11 wherein said bulk element further comprises a base portion which extends downward from said bottom surface, and wherein each of said hinge elements is coupled to said base portion.

15. A method of making a MEMS apparatus, comprising:

a) providing a device component comprising single-crystal silicon;

b) creating at least one hinge in said device component;

c) constructing a support component having a cavity;

d) bonding said device component to said support component, such that said at least one hinge is disposed within said cavity; and

e) forming in said device component a bulk element having a device surface and a bottom surface, whereby said at least one hinge is coupled to said bulk element and is disposed below said bottom surface, thereby suspending said bulk element from said support.

16. The method of claim 15 wherein said device component comprises an SOI (Silicon-On-Insulator) wafer having a single-crystal silicon device layer and a silicon handle wafer sandwiching an insulation layer, said single-crystal silicon layer having a first surface.

17. The method of claim 16 wherein said at least one hinge comprises first and second hinge elements, fabricated on said first surface of said single-crystal silicon device layer by a surface micromachining technique.

18. The method of claim 16 wherein said at least one hinge is created in said single-crystal silicon device layer by a bulk micromachining technique.

19. The method of claim 17 wherein said step d) further includes removing said silicon handle wafer along with said insulation layer, thereby revealing a second surface of said single-crystal silicon device layer.

20. The method of claim 19 wherein said step e) includes using a bulk micromachining technique to form said bulk element in said single-crystal silicon device layer, whereby said first and second surfaces of said single-crystal silicon device layer constitute said bottom and device surfaces of said bulk element.

21. The method of claim 15 further comprising the step of making said device surface optically reflective.

22. The method of claim 21 wherein said device surface is made optically reflective by depositing a reflective layer thereon.

23. The method of claim 15 wherein said device component comprises an epitaxial silicon wafer.

24. The method of claim 15 wherein said support component is fabricated out of an SOI wafer.

25. The method of claim 15 wherein said step c) further includes disposing at least one electrode in said cavity.

26. An optical apparatus comprising:

a plurality of MEMS devices configured in an array, wherein each MEMS device includes:

a) a bulk element having a device surface and a bottom surface, disposed below said device surface;

b) a support; and

c) at least one hinge, which is disposed below said bottom surface, and which is coupled to said bulk element and to said support, thereby suspending said bulk element from said support.

27. The apparatus of claim 26 wherein said bulk element comprises single-crystal silicon.

28. The apparatus of claim 26 wherein said at least one hinge comprises first and second hinge elements.

29. The apparatus of claim 26 wherein said at least one hinge is formed from a material selected from the group consisting of polysilicon, polyoxide, nitride, silicon nitride, silicon dioxide, silicon oxynitride, single-crystal silicon, and metals.

30. The apparatus of claim 26 wherein said device surface is optically reflective.

31. The apparatus of claim 26 wherein said support contains a cavity, and wherein said at least one hinge is disposed within said cavity.

32. The apparatus of claim 31 wherein said support further comprises at least one electrode disposed in said cavity, for causing said bulk element to be actuated.